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Laboratory Studies on the Toxicity of Tartar Emetic to the Mexican Fruitfly[1]

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SUMMARY

Tartar emetic, or potassium antimonyl tartrate ($KSbOC_4H_4O_6 . 1/2H_2O$) has been found useful for the control of various kinds of insects. Since 1932 its toxicity to a number of species of fruitflies, including the Mexican fruitfly (*Anastrepha ludens* (Loew)) has been studied, and has proved to be one of the most effective materials tested in the laboratory and in the field for the control of this insect.

Detailed descriptions of methods and procedure are given. Mortality records were obtained at approximately equal intervals at the logarithms of the hours from time of starting. The mean length of life of flies from each cage was read directly from the provisional regression line at a probit of 5.0 (50-percent point).

The mortality of fruitflies exposed to tartar emetic and sugar was more rapid in cages started at 6 a. m. than in those started at either 12 noon, 6 p. m., or 12 p. m. This would be expected, since flies feed mostly in the morning.

The mortality of flies exposed to tartar emetic and sugar in cages with capacities of 178 or 476 cubic inches was more rapid than in those with capacities of 1,055 or 1,792 cubic inches. The more rapid mortality of flies in the smaller cages in ascribed to the flies being confined in closer proximity to glass plates covered with poison.

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[1] The study on which this manuscript is based was conducted in cooperation with the Secretaría de Agricultura y Fomento, Mexico.

[2] Grateful acknowledgment is made to Donald F. Starr for his counsel on statistical methods of analysis.

Flies starved for 24 hours and then allowed food for 3 hours before exposure to tartar emetic and sugar died more rapidly than flies having continuous access to food or those allowed food for either 6 or 12 hours after a 24-hour starvation period and previous to exposure to poison. These experiments suggested the possibility of conditioning flies by starvation and subsequent feeding previous to exposure to insecticides in toxicity tests.

Four experiments on the toxicity of concentrations of tartar emetic ranging from 0.125 to 8 pounds in 100 gallons of solution containing 20 pounds of granulated sugar showed that decrease in the length of life of flies was not very great as the concentration was gradually increased from 2 to 6 or 8 pounds of tartar emetic. Flies succumbed less rapidly upon exposure to a concentration of 1 pound, and toxicity fell off markedly when flies were exposed to concentrations of less than 1 pound.

Tartar emetic at the rate of 4 pounds in 100 gallons of solution containing 20 pounds of granulated sugar was no more toxic to males than to females of *Anastrepha ludens* at any time during the course of several toxicity tests.

HISTORICAL REVIEW

In 1916 Headlee (*5*)[3] reported the use of a mixture of tartar emetic and sirup for the control of the pavement ant (*Tetramorium caespitum* (L.)). Since that time the use of tartar emetic for the control of various species of ants has been mentioned by several investigators. Tartar emetic, in combination with other materials, has also been found useful for the control of moths of the tobacco hornworm (*Protoparce sexta* (Johan.)), and the corn earworm (*Heliothis armigera* (Hbn.)), and for the control of the gladiolus thrips (*Taeniothrips simplex* (Morison)), the citrus thrips (*Scirtothrips citri* (Moult.)) on lemons, and common red spiders (*Tetranychus* spp.). Tartar emetic was ineffective for the control of carpenter ants (*Camponotus* spp.) living in telephone poles and the pecan weevil (*Curculio caryae* (Horn)).

Zetek,[4] working with S. A. Forbes in Illinois between 1907 and 1911, found that adult houseflies (*Musca domestica* L.) and other flies were controlled when piles of garbage and manure were sprayed with tartar emetic and sugar. In 1932 Zetek[5] tested the toxicity of tartar emetic and molasses sprays to fruitflies (*Anastrepha serpentina* Wied., *A. mombinpraeoptans* Seín (*fraterculus* (auct.)), and *A. striata* Schin.) in the insectary at Balboa, Panama Canal Zone. Later in the same year cage tests by McBride[6] in Hawaii showed that when adults of the Mediterranean fruitfly (*Ceratitis capitata* (Wied.)) were exposed to sweetened sprays containing tartar emetic, mortality was rapid. The United States Bureau of Entomology and Plant Quarantine (*11*) reported that tartar emetic was more toxic to adults of *C. capitata* in Hawaii than were nicotine compounds, copper arsenite, copper tartrate, copper sucrate, cadmium salts, and lead arsenate. The toxicity of tartar emetic to *C. capitata* under field conditions in

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[3] Italic numbers in parentheses refer to Literature Cited, p. 13.

[4] ZETEK, J. Personal correspondence with A. C. Baker, July 24 and September 18, 1940.

[5] ZETEK, J. U. S. Bur. Ent. Panama Canal Zone Lab. Prog. Rpt., 4 pp., April 1932. [Unpublished.]

[6] MCBRIDE, O. C. U. S. Bur. Ent. Hawaii. Lab. Prog. Rpt., p. 2, October 1932. [Unpublished.]

Hawaii was studied by McBride and Marlowe.[7] In this connection, the United States Bureau of Entomology (*10*) mentioned that tests in citrus and mango groves showed that, even under conditions of general infestation, considerable protection was obtained by repeated applications of sweetened sprays containing tartar emetic.

In 1933 McAlister (*6*) and Wadley (*14*) described the effectiveness of tartar emetic and molasses sprays for the control of West Indian fruitflies (*Anastrepha mombinpraeoptans* (*acidusa* Walk.) and *A. suspensa* Loew) in Key West, Fla. The United States Bureau of Entomology (*9*), Newell (*7*), and Spencer and Osburn (*8*) have touched upon the same subject.

Baker [8] found tartar emetic toxic to the Mexican fruitfly in laboratory tests. Subsequent studies conducted by Baker et al. (*2, p. 105*) in the laboratory and the field were mentioned by the United States Bureau of Entomology and Plant Quarantine (*12, 13*) and by Baker.[9] Detailed field studies were reported by Plummer, Monk, and Shaw.[10]

Marlowe [11] tested tartar emetic for the control of the melon fly (*Dacus cucurbitae* (Coq.)) in Hawaii. Recently Allman (*1*) reported that tartar emetic and sodium fluosilicate sprays were superior to lead arsenate sprays in cage tests made with the Queensland fruitfly (*Dacus* (*Strumeta*) *ferrugineus tryoni* Frogg.).

LABORATORY STUDIES

METHODS

Cages of three sizes were required in connection with these studies. All were of similar construction, with wooden frame, fixed-glass top, sliding-glass front, and muslin cloth nailed to the frame on the three remaining sides. The cages were designated as (1) emergence cages, (2) holding cages, and (3) toxicity cages. Double emergence cages were constructed, the inside dimensions of each cage being approximately 12 by 12 by 12 inches. Several hundred flies were allowed to emerge from puparia held in each cage and were confined for an indefinite period, usually 10 to 15 days.

A week or two before the toxicity tests were started 600 flies of each sex were transferred by means of a suction device from several emergence cages to a holding cage which is a pair of emergence cages with the inside partition removed. The flies in each holding cage constituted a single culture (Bliss, *4*). Definite numbers of fruitflies were transferred from holding cages to toxicity cages. Three toxicity cages were constructed together, and each individual cage had inside measurements approximating 12 inches in height, 12¼ inches in depth, and 7¼ inches in width. Groups of 10 flies, in equal numbers of each sex, were transferred to each toxicity cage, and this procedure was repeated until there were 50 flies in a cage. Most toxicity tests required the removal of 1,000 or 1,050 flies from a single culture.

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[7] McBride, O. C. and Marlowe, R. H. U. S. Bur. Ent. and Plant Quar. Hawaii. Lab. Ann. Rpt. (1934), pp. 9–10. 1935. [Unpublished.]

[8] Baker, A. C. U. S. Bur. Ent. Mex. Lab. Prog. Rpt. 52, p. 3. 1933. [Unpublished

[9] Baker, A. C. SPRAYING FOR THE MEXICAN FRUITFLY. U. S. Bur. Ent. and Plant Quar., 4 pp. 1937. [Processed.]

[10] Plummer, C. C., Monk, J. W., and Shaw, J. G. FIELD STUDIES ON INSECTICIDES FOR THE MEXICAN FRUITFLY DURING THE SEASON OF 1938–39. U. S. Bur. Ent. and Plant Quar. Mex. Lab. Rpt. 153–SR, 46 pp., illus. 1940. [Unpublished.]

[11] Marlowe, R. H. Territory Hawaii Trust Fund Mo. Rpt. (Dec. 1935), pp. 16–17. 1936. [Unpublished.]

The remaining flies in the culture were retained under the same conditions as flies in toxicity cages and were used for the replacement of flies that died in toxicity cages prior to exposure to poison. It was necessary to transfer flies from 2 or more holding cages or cultures when more than 1,050 flies were required in a toxicity test. In such instances each toxicity cage was supplied with the same number of flies from each of 2 or more cultures. Freshly cut pieces of orange, cube sugar, and water were present in all cages, including toxicity cages, until the toxicity tests were started.

Emergence and holding cages were held at room temperature. Toxicity cages and holding cages containing flies for replacements were kept in a large air-conditioned and naturally lighted cabinet for at least 24 hours prior to the starting of toxicity tests. A constant temperature of 25° C. (77° F.) and relative humidity close to 30 percent were maintained in the cabinet. The tests, as a rule, were begun at 6 p. m. by the removal of sugar and orange and the introduction of a glass plate covered with insecticidal material into each cage. Treatments were assigned to the cages at random. Cages were removed in random order from the cabinet for recording fly mortality, changing plates, and adding water to the containers of absorbent cotton.

Spray materials were weighed in grams with an accuracy of 1:10,000, and solutions were made up to volume with distilled water. Five milliliters of solution was pipetted on to each glass plate. The plates measured 4 by 6 inches and were about one-eighth inch thick. The top surface was covered with numerous conelike elevations about 0.02 inch high and about 0.06 inch in diameter at the base. The channels around the elevations were close to 0.02 inch in width. This surface permitted the spreading of solutions to the edges of a clean plate with little danger of its running off. Solutions were allowed to dry thoroughly before the plates were used in toxicity tests. Glass plates were changed approximately every 2 days in all cages, regardless of the number of flies that survived.

Prior to the adoption of the methods described herein, the practice was to record mortality of flies twice daily, at 9 a. m. and at 6:30 or 7 p. m. This procedure was changed when it was learned that toxicity data could be analyzed more satisfactorily if percentages of mortality were first converted to probits (Bliss, *3*). On cross-section paper the probits were then plotted against lengths of exposure expressed as logarithms of hours. Equal arithmetical spacing of the observation times resulted in unequal spacing of points plotted with such a system of coordinates. The logarithms of observation times for the experiments described in this circular are almost equally spaced after the third day (table 1). In subsequent studies on other compounds all observations were equally spaced logarithmically.

Complete mortality data from each cage (plot) were converted to probits, plotted in the manner previously described, and the provisional regression line drawn. The time of 50-percent mortality of fruitflies in each cage was read directly from the line at probit 5.0. Most time-mortality curves fitted by eye were surprisingly close to calculated curves and are sufficiently accurate for studies on the toxicity of insecticides to fruitflies. One feature of the probit-log-time curve, as drawn for toxicity data on the Mexican fruitfly, is that the lower end of it is sometimes broken. In such instances two straight lines need to be drawn to represent the data properly. Fortunately, most of the breaks studied so far were lower-end ones and most points of such breaks fell below probit 5.0. When a change in slope requires that two lines be drawn for one set of data, one of them is likely to pass through the mean time of kill at probit 5.0, and the reading can be made at that point.

TABLE 1.—*Procedure followed for the timing of observations on the mortality of Mexican fruitflies in toxicity tests*

Observations reckoned from 6 p. m.		Hours	Logarithm of hours
Time	Day[1]		
6:19 p. m	1st	0.31	−0.50864
7:56 p. m	1st	1.94	.28780
10:00 p. m	1st	4.00	.60206
12:35 a. m	2d	6.59	.81889
3:51 a. m	2d	9.85	.99366
7:57 a. m	2d	13.95	1.14457
1:07 p. m	2d	19.12	1.28148
7:37 p. m	2d	25.62	1.40858
3:49 a. m	3d	33.81	1.52905
2:07 p. m	3d	44.12	1.64464
3:06 a. m	4th	57.10	1.75664
7:26 p. m	4th	73.43	1.86588
4:00 p. m	5th	94.00	1.97313
5:53 p. m	6th	119.89	2.07878
2:29 a. m	8th	152.49	2.18324
7:32 p. m	9th	193.53	2.28675
11:11 p. m	11th	245.19	2.38951
4:14 p. m	14th	310.23	2.49168
2:07 a. m	18th	392.11	2,59341
9:11 a. m	22d	495.19	2.69477
6:58 p. m	27th	624.96	2.79585
2:20 p. m	34th	788.33	2.89671
4:00 a. m	43d	994.00	2.99739

[1] Beginning of experiment considered as first day.

The mean mortality of flies, as read from regression lines, was tabulated by cages (plots) under the several treatments prior to the analysis of variance. The term "average mean length of life" refers to the averages of all means included in a single treatment. Few fruitflies—usually less than 10 percent in a period of 20 or more days—died in control cages where they were exposed to dried solutions prepared with granulated sugar at the rate of 20 pounds in 100 gallons of aqueous solution. Mortality records from control cages were incomplete in that all flies did not die. For this reason comparisons could not be made with the complete mortality data recorded from toxicity cages.

EXPERIMENTS ON TIME TO BEGIN TOXICITY TESTS

An experiment on the best time to begin toxicity tests was one of several designed to perfect methods for studying the toxicity of insecticides to the Mexican fruitfly. It comprised four cages (plots) in each of four treatments. Fruitflies 16 to 25 days old were exposed to tartar emetic used at the rate of 4 pounds in 100 gallons of aqueous solution containing 20 pounds of granulated sugar. A group of four cages of flies was started at 6 a. m., the second group at 12 noon, the third group at 6 p. m., and the fourth group at 12 p. m. The intervals of time between observations were the same as those listed in table 1 except that they were advanced 12 hours to make 6 a. m. the nominal time of starting. Observations on the mortality of the flies were continued in regular sequence and were not modified by the starting of additional groups of cages after the first group. The logarithm of the mean length of life of flies in each cage, as taken from the probit-log-time curve, was adjusted in tests started after 6 a. m. These adjustments were for 6 hours for data recorded from cages started at 12 noon, 12 hours for those started at 6 p. m., and 18 hours for those started at 12 p. m. The adjusted data are summarized in table 2, experiment 1.

TABLE 2.—*Mean length of life under controlled conditions of Mexican fruitflies exposed to tartar emetic and sugar in tests begun at 4 different hours of the day*

Test begun at—	Length of life after treatment			
	Experiment 1		Experiment 2	
	Log-hours	Average mean [1]	Log-hours	Average mean [2]
6 a. m.	1.552 1.570 1.605 1.500	1.5567	1.542 1.522 1.561 1.577	1.5505
12 noon	1.599 1.679 1.734 1.723	1.6837	1.622 1.576 1.633 1.633	1.6160
6 p. m.	1.671 1.781 1.696 1.817	1.7413	1.646 1.594 1.683 1.607	1.6325
12 p. m.	1.695 1.695 1.695 1.668	1.6883	1.553 1.582 1.597 1.568	1.5750

[1] Required difference between means at $P=0.05$ is 0.0793.
[2] Required difference between means at $P=0.05$ is 0.0444.

The difference between the average mean length of life after treatment started at 6 p. m. and the average mean length of life after treatment started at 6 a. m. was highly significant. Differences attributed to treatments started at 6 p. m. and either 12 noon or 12 p. m. were not significant.

A replicate experiment on time of starting was run concurrently with the first one. In this instance the fruitflies were 30 to 31 days old when the experiment was started. The data are summarized as experiment 2 in table 2. The difference between the average mean length of life of flies in cages started at 6 p. m. and the mean for those started at 6 a. m. was highly significant in this experiment. In contrast to the former experiment, however, a significant difference was shown between the average for cages started at 6 p. m. and that for cages started at 12 p. m.

The survival of flies for a shorter period of time when treatment was started at 6 a. m. would be expected in view of the well-established observation that flies feed mostly in the morning. Conditions are made as favorable as possible for the survival of flies in tests on toxicity. For this reason 6 p. m. was chosen as the time for starting future toxicity tests.

Experiments on Size of Test Cages

Experiments were performed to determine whether the size of the cage would affect the mean length of life of fruitflies exposed to tartar emetic used at the rate of 4 pounds in 100 gallons of aqueous solution containing 20 pounds of granulated sugar. The only departure from standard technique was occasioned by the small mouth of glass jars used for one type of cage. This necessitated the use of two plates, each 3 by 4 inches, in each jar, in place of the standard 4- by 6-inch plate. Each of the smaller plates was covered with half the standard amount of solution.

Descriptions of the four types of cages are as follows: (1) One-partition type: Two compartments with glass top and front, muslin-covered sides, and wooden bottom. Constructed with none of the wooden frame exposed inside the cage. Each compartment, by inside measurements, approximately $12\frac{3}{16}$ inches high, $12\frac{1}{8}$ inches deep, and $12\frac{1}{8}$ inches wide. The inside capacity of the cage was 1,792 cubic inches. (2) Two-partition type: Standard cage used in toxicity tests and described under Methods (p. 3). The inside capacity of the cage, excluding the frame, was 1,055 cubic inches. (3) Square cage designed by E. W. Baker: Single compartment, with glass front, top and sides covered with cheesecloth, and wooden bottom. By inside measurements approximately $7\frac{7}{8}$ inches high, $7\frac{15}{16}$ inches deep, and 8 inches wide. The inside capacity of the cage, excluding the frame, was 476 cubic inches. (4) Glass jar: Rectangular in shape with $3\frac{1}{2}$-inch round opening at one end, the opening covered with mosquito netting held in place by a rubber band. By outside measurements the jar was approximately 5 inches high, $9\frac{1}{2}$ inches long, and 5 inches wide. Its inside capacity, excluding the volume of a small block of wood used to support the container of moistened absorbent cotton, was 178 cubic inches. The results of this experiment are summarized in table 3.

Table 3.—*Mean length of life under controlled conditions of Mexican fruitflies held in cages of 4 different sizes and exposed to tartar emetic and sugar*

Capacity of cage (cubic inches)	Length of life after treatment			
	Experiment 1		Experiment 2	
	Log-hours	Average mean [1]	Log-hours	Average mean [2]
1,792	1.591 1.392 1.391 1.421	1.4487	1.550 1.575 1.562 1.543	1.5575
1,055	1.518 1.450 1.445 1.554	1.4917	1.526 1.500 1.567 1.489	1.5205
476	1.313 1.357 1.344 1.398	1.3530	1.488 1.500 1.448 1.427	1.4657
178	1.428 1.415 1.300 1.334	1.3693	1.380 1.320 1.333 1.435	1.3670

[1] Required difference between means at $P = 0.05$ is 0.1007.
[2] Required difference between means at $P = 0.05$ is 0.0562.

No significant difference was shown between the length of life of flies in standard cages (capacity, 1,055 cubic inches) and that in larger cages having capacities of 1,792 cubic inches. Differences between the length of life of flies in standard cages and flies in cages with capacities of 476 and 178 cubic inches, respectively, were significant. The experiment on sizes of test cages was replicated. The data are summarized as experiment 2 in table 3. It was found that only the difference associated with the standard cage and with the cages having capacities of 178 cubic inches was highly significant. The other comparisons indicated nonsignificance.

Certain disparities were shown when the results of these two experiments were compared. The logarithm of the average mean length of life of flies in the smaller cages tended to be less than that for flies in the larger cages. This would be expected insofar as flies confined in the smaller cages were in closer proximity to glass plates covered with tartar emetic and sugar. An unconsidered factor was that cages were of different construction. The important results were that in both experiments there was no significant difference between the average mean length of life of flies in the two large cages, one of which was the standard cage used in toxicity tests.

Experiments on Alternately Starving and Feeding Fruitflies Prior to Starting Toxicity Tests

Experiments were designed to study the effect of previous feeding of flies on their mean length of life upon exposure to tartar emetic used at the rate of 4 pounds in 100 gallons of aqueous solution containing 20 pounds of granulated sugar. Flies were kept in toxicity cages at 25° C. and supplied with cube sugar and freshly cut pieces of orange in the usual manner from June 7 until June 11. Beginning on June 11, treatments differed until glass plates were introduced at the beginning of toxicity tests. The treatments were as follows: (1) Flies kept without food for 24 hours (6 a. m. June 11 to 6 a. m. June 12) and then given food for 12 hours (June 12, 6 a. m. to 6 p. m.) prior to the starting of toxicity tests; (2) flies kept without food for 24 hours (12 m. June 11 to 12 m. June 12) and then given food for 6 hours (June 12, 12 m. to 6 p. m.) prior to the starting of toxicity tests; (3) flies kept without food for 24 hours (3 p. m. June 11 to 3 p. m. June 12), and then given food for 3 hours (June 12, 3 p. m. to 6 p. m.) prior to the starting of toxicity tests; (4) flies held in the customary manner, with no starvation period.

Water was supplied in all cages at all times. Flies that died in starvation cages were not replaced. The data on these experiments and the results of the analyses are contained in table 4.

The average means of lengths of life fall in the same order in respect to size in experiment 2 of table 4 as in experiment 1 of the same table. The differences of the logarithms of the average mean length of life of flies subjected to the standard treatment (i. e., allowing food to remain in cages continuously until the start of toxicity tests) from the logarithms of the average mean length of life of flies having 12 hours' exposure to food following a starvation period of 24 hours were highly significant in both experiments. Comparison of results from the standard treatment and the 6-hour exposure showed that in only one case was the difference significant. The logarithms of the average mean length of life of flies exposed to food for 3 hours after the starvation period were less than the mean length of life in the standard treatment, and significantly less in experiment 1.

TABLE 4.—*Mean length of life under controlled conditions of Mexican fruitflies starved for 24 hours, followed by access to food for 3 to 12 hours prior to exposure to tartar emetic and sugar*

Period of access to food following 24 hours' starvation (hours)	Length of life after treatment			
	Experiment 1		Experiment 2	
	Log-hours	Average mean [1]	Log-hours	Average mean [2]
12	1.730 1.690 1.621 1.710	1.6877	1.669 1.672 1.653 1.734	1.6820
6	1.686 1.651 1.640 1.689	1.6665	1.640 1.595 1.545 1.583	1.5907
3	1.481 1.567 1.525 1.463	1.5090	1.518 1.568 1.528 1.524	1.5345
No starvation	1.589 1.589 1.580 1.636	1.5985	1.596 1.573 1.532 1.542	1.5607

[1] Required difference between means at $P=0.05$ is 0.0580.
[2] Required difference between means at $P=0.05$ is 0.0497.

The results of these experiments suggest the possibility that some method of conditioning flies by starvation and subsequent feeding before starting toxicity tests might be an improvement over the standard technique of supplying food continuously to the flies before starting the tests.

EXPERIMENTS ON THE TOXICITY OF DIFFERENT CONCENTRATIONS OF TARTAR EMETIC

EXPERIMENT 1

Former methods were followed in conducting the present experiment on the toxicity of concentrations of tartar emetic ranging from 1 to 6 pounds, respectively, in 100 gallons of aqueous solution containing 20 pounds of granulated sugar. The principal point of departure from methods used in all the other studies mentioned here was that records on mortality were taken daily at about 9 a. m. and again at 6:30 to 7 p. m. All flies came from a single culture. The data are summarized in table 5. In this experiment differences between treatments were not significant.

TABLE 5.—*Mean length of life under controlled conditions of Mexican fruitflies exposed to different concentrations of tartar emetic mixed with 20 pounds of granulated sugar in 100 gallons of solution*

Tartar emetic in 100 gallons of solution (pounds)	Length of life after treatment			
	Experiment 1		Experiment 2	
	Log-hours	Average mean	Log-hours	Average mean [1]
1.0	1.814	1.7247	1.826	1.8053
	1.738		1.905	
	1.622		1.685	
2.0	1.670	1.6783	1.742	1.7653
	1.587		1.755	
	1.778		1.799	
3.0	1.673	1.6703	1.660	1.6950
	1.678		1.752	
	1.660		1.673	
4.0	1.662	1.6957	1.784	1.7723
	1.710		1.813	
	1.715		1.720	
5.0	1.648	1.6813	1.818	1.7850
	1.684		1.764	
	1.712		1.773	
6.0	1.669	1.6983	1.700	1.6130
	1.702		1.590	
	1.724		1.549	

[1] Required difference between means at $P=0.05$ is 0.1149.

EXPERIMENT 2

The experiment on six different concentrations of tartar emetic was replicated using standard methods. A summary of the data is given in table 5.

In this experiment, however, differences between the logarithm of mean length of life of flies exposed to several concentrations of tartar emetic were significant. The average mean length of life for both 3 pounds and 6 pounds appears to be much below the trend shown by data for the four other concentrations. The reason for this is unknown. Moreover, the difference between the value for 6 pounds and that for each of the other concentrations, except 3 pounds, was significant or highly significant when tested by t. If, however, t is used to test the difference between the average mean length of life of flies exposed to 5 pounds of tartar emetic, a value closer to the trend, and a similar datum for each of the other concentrations, only the difference between the mean for 5 pounds and that for 6 pounds is great enough to attain significance. Analysis of variance of these same data, with those on the concentration of 6 pounds omitted, failed to show significant differences between treatments.

EXPERIMENT 3

A third experiment covered concentrations of tartar emetic ranging from 0.125 to 8 pounds in 100 gallons of solution containing 20 pounds of granulated sugar. A summary of the data is given in table 6.

By use of the t test it was shown that differences between the logarithm of the average mean length of life of flies exposed to a concentration of 8 pounds of tartar emetic, and the logarithms for those exposed to concentrations of 0.125, 0.250, and 0.500 pound, respectively, were highly significant. No significant differences were shown between the mean for 8 pounds and the means for the remaining concentrations tested, namely, 1, 2, 4, and 6 pounds, respectively.

TABLE 6.—*Mean length of life under controlled conditions of Mexican fruitflies exposed to different concentrations of tartar emetic mixed with 20 pounds of granulated sugar in 100 gallons of solution.*

Tartar emetic in 100 gallons of solution (pounds)	Length of life after treatment		Tartar emetic in 100 gallons of solution (pounds)	Length of life after treatment	
	Log-hours	Average mean[1]		Log-hours	Average mean[1]
0.125	2.055	2.1138	2.0	1.515	1.5786
	2.179			1.558	
	2.092			1.549	
	2.125			1.608	
	2.118			1.663	
0.250	1.999	1.8562	4.0	1.564	1.5610
	1.790			1.622	
	1.861			1.419	
	1.822			1.598	
	1.809			1.602	
0.500	1.805	1.7182	6.0	1.545	1.5650
	1.699			1.552	
	1.650			1.600	
	1.705			1.610	
	1.732			1.518	
1.0	1.545	1.6112	8.0	1.378	1.5446
	1.599			1.643	
	1.736			1.627	
	1.575			1.547	
	1.601			1.528	

[1] Required difference between means at $P=0.05$ is 0.0915.

EXPERIMENT 4

A fourth experiment considered concentrations of tartar emetic ranging from 0.125 to 0.750 pound in 100 gallons of aqueous solution containing 20 pounds of granulated sugar. Mortality data are shown in table 7.

Differences between the logarithm of the average mean length of life of flies exposed to a concentration of 0.750 pound of tartar emetic and the logarithm of the average mean length of life of flies exposed to 0.500 pound were significant, whereas differences between the longevity of flies exposed to 0.750 pound and those exposed to 0.250 and 0.125 pound, respectively, were highly significant.

TABLE 7.—*Mean length of life under controlled conditions of Mexican fruitflies exposed to different concentrations of tartar emetic mixed with 20 pounds of granulated sugar in 100 gallons of solution*

Tartar emetic in 100 gallons of solution (pounds)	Length of life after treatment		Tartar emetic in 100 gallons of solution (pounds)	Length of life after treatment	
	Log-hours	Average mean[1]		Log-hours	Average mean[1]
0.125	2.265	2.2555	0.500	1.827	1.8035
	2.275			1.786	
	2.241			1.835	
	2.241			1.766	
0.250	1.973	1.9390	0.750	1.728	1.7257
	1.945			1.660	
	1.952			1.805	
	1.886			1.710	

[1] Required difference between means at $P=0.05$ is 0.0616.

Toxicity data on different concentrations of tartar emetic were recorded from 92 cages containing approximately 4,400 flies, exclusive of controls. The antilogarithms of average mean length of life of flies in the four experiments on concentration of tartar emetic (tables 5, 6, and 7) were plotted on cross-section paper against the concentration of tartar emetic (fig. 1). A constantly changing decrease in length of life of flies is shown as the concentration is increased. No attempt was made to draw a line through the scattered distribution of the data from experiment 2. The figure also illustrates the variation in the mortality of flies from different cultures when exposed to a given concentration of tartar emetic.

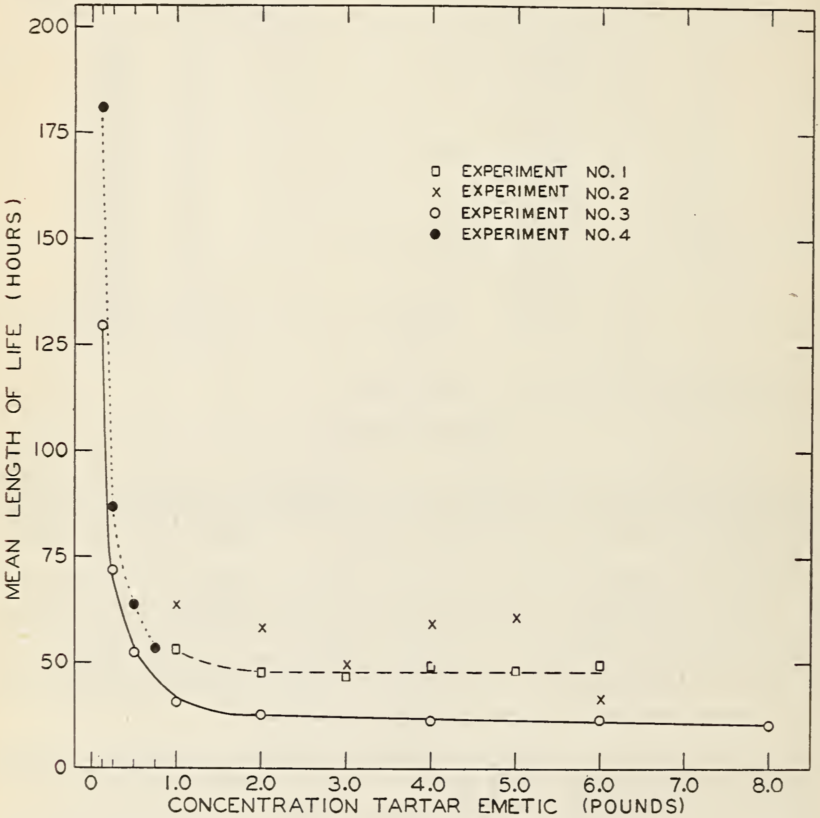

Figure 1.—Relationship between concentration of tartar emetic, in pounds per 100 gallons of aqueous solution containing 20 pounds of granulated sugar, and the average mean length of life of the Mexican fruitfly at 25° C. and approximately 30 percent relative humidity.

Toxicity of Tartar Emetic to Males and Females

Data taken by former methods at 25° C. from 6 series of toxicity tests comprising 22 cages of flies were tested by chi-square to determine whether there was any evidence to show that tartar emetic used at the rate of 4 pounds in 100 gallons of aqueous solution containing 20 pounds of granulated sugar was more toxic to one sex than to the other. It is shown (table 8) that chi-square calculated for any interval, and with 1 degree of freedom, did not exceed the 10-percent point of 2.706. Chi-square for 12 intervals and with 12 degrees of freedom was 7.813 and *P* was 0.8. Differences in toxicity to males and females would be considered significant if this value were as great as, or greater than, 21.026 (5-percent point, 12 *df*). The conclusion drawn from these data is that tartar emetic at the concentration tested was definitely no more toxic to one sex than to the other at any time during the course of these particular toxicity tests.

TABLE 8.—*The mortality of males and females of the Mexican fruitfly exposed to tartar emetic and sugar. Tests at 25° C. and approximately 30 percent relative humidity. Chi-square values tested the hypothesis of a 0.498:0.501 susceptibility of the sexes to the poison*

Interval after start of tests (hours)	Mortality			Chi-square
	Males	Females	Total	
	Number	*Number*	*Number*	
0 to 14	15	19	34	0.451
14 to 24	28	23	51	.514
24 to 38	39	35	74	.236
38 to 48	85	86	171	.002
48 to 62	56	72	128	1.924
62 to 72	57	57	114	.001
72 to 86	51	42	93	.915
86 to 96	28	31	59	.139
96 to 110	21	18	39	.245
110 to 120	20	13	33	1.519
120 to 134	18	16	34	.127
134 to 144	5	12	17	
144 to 158	5 } 14	7 } 22	12 } 36	1.740
158 to 168	4	3	7	
Total	432	434	866	[1] 7.813

[1] For 12 degrees of freedom, $P=0.80$.

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